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AMERICAN GEOLOGY, 1850–1900[1]

By Dr. BAILEY WILLIS

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In 1850 the knowledge of geology was in an early exploratory stage, especially in America. In England and Europe sufficient progress had been made in the study of the stratified rocks and their contained fossils to contrast markedly with American lack of observations. It could not have been otherwise. The first task of a geologist, entering upon a new field, is to discover and locate the various rock formations. He must have a map, upon which to delineate their distribution. But in 1850 the mapping of America was very crude. Even the eastern country was known only in broad outline and the west was imperfectly explored. Nevertheless, by 1850, material progress had been made in determining the ages and distribution of the sedimentary rocks of the United States east of the Mississippi and of Canada. Logan of Canada, Hall of New York, the Rogers brothers of Pennsylvania and Virginia, Safford of Tennessee, and many others who felt the urge to read the record in the rocks, had identified the strata of certain great periods of geological time, had classified them in order of relative age, and had mapped them with such accuracy as the conditions permitted.

That they had been able to accomplish so much was in part due to the fact that the great leaders in English geology, Sedgewick and Murchison, had established for that country a succession of strata and fossils, which is the same as that of eastern North America.

[1] Abstract of address before the American Philosophical Society, February, 1942.

It may not be assumed that the similarity is a matter of course. Had the Americans been studying the Pacific side of the continent they would have found great dissimilarities. But it is fact, though as yet unexplained, that each ocean basin has been the scene of similar physical changes, contemporaneously, throughout geological history. Thus it happened that the Americans were able to identify in America that succession of strata and fossils which might be designated the North Atlantic sequence. It became the standard and the chronology of world history has since been written in terms of its record.

Among the large number of paleontologists who worked to read this geological record James Hall of New York became the recognized leader, while James D. Dana, through his wide, comprehensive knowledge of the science and his facilities for publication, developed a clearing house for the exposition of geology. His "Manual of Geology" was a compendium of all branches of the science from the first edition in 1866 to the sixth and last in 1897. As a college student in the late eighteen-seventies had I been asked why the globe was cooling and contracting I might have answered: Because Dana says so.

With this too brief reference to the great achievement of establishing the standard geological time scale for America and laying the foundations of a general knowledge of American geology, we must here turn to other branches of the science.

How old is the earth? That was a much discussed question during the latter half of the nineteenth century. At any earlier date the catastrophists could dismiss it with a reference to Genesis. Dana himself in 1863, in comparing the Biblical and geological records of Creation, interpreted the "day" of Genesis as the equivalent of geological eras and maintained that there could be no conflict between the two because both were of the same divine origin. But estimates based on the recession of Niagara Falls and the growth of coral reefs in the Pacific persuaded him that "time is long—even when the earth is hastening toward its last age." In this opinion he agreed with certain early estimates put forward on biological grounds. Darwin thought that evolution had required 200,000,000 years to reach the development of modern forms of life. But Lord Kelvin, estimating the cooling of the earth from a molten state, concluded that not more than 40 nor less than 20 million years had passed since a crust had begun to form. We now know upon much sounder grounds, by the rate of radioactive alterations, that 2,000 million years is a minimum age for the earth in the state we now observe.

Many estimates of geological time were based upon the rates of erosion and deposition of sediments. It was considered possible to approach the one factor by studies of the sediment carried by rivers and to guess approximately how long it had taken to deposit a foot of sandstone or shale or limestone. There was the underlying assumption that the rates had been roughly uniform and that the actual conditions represented those of past ages. Powell and his disciple, William M. Davis, founders of the science of physiography, showed the fallacy of that assumption. When Powell observed the ferocity of erosion in the Grand Canyon of the Colorado, he was almost shocked. Such tremendous gorges, carved in so brief an epoch of geological time! He grasped the concept of recent uplift; he foresaw a slowing down as the height should be worn away; he sensed the inevitable result—that the plateau must be reduced to a low surface, a uniform plain—; and he recognized that erosion must then wait upon renewed activity of lifting forces. Thus he came to recognize what he afterwards always taught: that the processes of erosion follow a cycle, comprising uplift, degradation, and sedimentation; and that such a cycle is but a brief interval between long periods when erosion is almost at a standstill.

Powell had philosophized regarding the processes of erosion. W. M. Davis analyzed them in detail. He dissected landscapes, distinguishing youthful, mature and aged forms, and he thus set up the concepts of youth, maturity and old age as stages that might be recognized in canyons, valleys, hills and plains. He established a purely American branch of geology, physiography. It provides a script by which he who runs may read the record of mountain growth. Mountains had been the symbol of the everlasting. They have come to be regarded as evidences of recent, transitory activity of the earth's internal forces. There have been many epochs of mountain growth. Since the most remote ages great uplifts have been raised and being eroded they have vanished from the scene. The activity is evident to-day. The Alps, the Rockies, the Himalayas are young. The grandest are among the youngest.

It has indeed been inspiring to follow Davis in reading the history of the Appalachians, where we began, and also of the mountains of Europe, Asia, Africa, South America, like an open book, in company with Davis's thought; but one inevitably follows Powell to the sources of that power which is so manifest in them. We get a new point of view. The action is recent, is even now at work. It is on a grand scale, as grand or grander than ever in the past. Can the force then be decadent? Is it running down? Is the earth a dying globe, "hastening on toward its last age" (Dana)? Thus the whole theory of terrestrial dynamics, as it was entertained during the last century, as a deduction from the Laplacian idea of the origin of the solar system, was challenged by a better understanding of the surface features, which had

always been open to investigation. That was the contribution of Powell, Gilbert and Davis.

Mountains have long offered another series of problems, those relating to their architectural structures. They are essentially mechanical. Given a force, some force, competent to do the work, how could it act to push up such enormous masses of strata, to force them up out of their original positions in the crust? The ideas involved are those of fracturing and folding on a grand scale. During the latter half of the nineteenth century they developed into that branch of the science that is known as structural geology.

The architecture of the Alps inspired the early students of that branch. The grandly majestic mountains may well seem awesome to many still, as they did to all men in the past; but to the daring few who began two centuries ago to seek to know them more intimately and to the many since, the Alps have revealed secrets which surpassed understanding. To the geologist who knows that normally beds of sandstone and limestone occur as flat sheets, in orderly sequences, they present the phenomenon of strata bent into huge folds without a break, or strangely fractured and forced over one another in apparent confusion. The effects of enormous forces, acting under abnormal conditions, stagger the imagination and long defied analysis. A Swiss, Albert Heim, was the first to reason out the principle, which is now a truism, that any bed of rock, however strong and rigid, may be bent without breaking, provided that it be so loaded that it can not separate. He also saw that solid rock had flowed under adequate pressure, where adequately confined, and that it had recrystallized during such movements. In his beautiful volume, "Das Mechanismus der Gebirgsbildung," 1878, he opened the way to understanding the changes of form and relations that are forced upon masses of rock in the movements of rising mountains.

In America the belt of the Appalachian mountains presents an unusually simple system of long, narrow folds. The folded rocks are bedded sandstone, shales and limestones, which were piled up to thicknesses exceeding twenty thousand feet. They were spread in flat sheets. They are now bent into arches and troughs, in alternation, like wrinkled paper. The brothers, H. D. and W. B. Rogers, executing the geological surveys of Pennsylvania and Virginia during two decades before 1850, observed the folding. The effect is that which would be produced if the belt had been narrowed by compression, but the Rogers brothers thought it impossible that simple compression could have so acted. They conceived a compound action, a combination of vertical and horizontal forces, like rising and falling waves; and they found a not unreasonable cause in the agitation of a thin crust, floating upon a molten interior. Their inferences were consistent with the then ruling ideas of a molten globe and of catastrophic activity of terrestrial forces. They have slowly given way to understanding of the fact that the processes of change are deliberate. The violent earthquake, the volcanic explosion are local, trivial incidents in the creeping operations of terrestrial forces.

Before we can do justice to the ingenuity with which the problems of mountains and their uplift were attacked during the nineteenth century we needs must consider the ideas of terrestrial dynamics that prevailed, and which, indeed, are by no means obsolete to-day.

It was not doubted that the Laplacian theory of the origin of the solar system was essentially correct and its corollary that the earth had cooled from a molten state was a basic assumption. Dana wrote (Manual, 1863, page 739):

> The earth in igneous fusion had no more distinction of parts than a germ. Afterwards the continents, while still beneath the waters, began to take shape. Then as the seas deepened, the first dry land appeared, low, barren, and lifeless. Under slow intestine movements and the concurrent action of the enveloping waters, the dry land expanded, strata formed, and as these processes went on, mountains by degrees rose, each in its appointed place.

Unfortunately for the theory the assumption of a thin crust floating on a fluid interior was mistaken, as was subsequently demonstrated by the geophysicists. Kelvin in 1862 calculated the effect of tidal attractions and showed that the earth must be as rigid as steel to resist them, as it does.

The contraction theory of mountain building, which Dana attributed to Newton, but which he developed, is the hypothesis which was most favorably considered during the half century with which we are dealing; it is still preferred by some geologists. It rests upon the assumption that the globe is cooling and therefore shrinking, bodily; and as the body shrinks it leaves the crust unsupported until the weight of the latter causes it to collapse and push up mountain masses. Dana supported the theory from the date of his first publication on the subject in 1847 to his death in 1897. On the other hand, it was strongly attacked on the ground that any possible contraction of the globe was quite inadequate to account for the observed shortening of the crust. The close of the century found the contraction theory still a subject of debate, with opinion running against it with such students as Dutton, Van Hise and Chamberlin.

Among the contemporaries of the contraction theory was the gravitation theory of James Hall. That paleontologist had observed that the Paleozoic strata of eastern North America had been compressed and folded where they were thick, *i.e.*, in the Appalachian belt, whereas they had remained undisturbed where

they were thin, as in the upper Mississippi valley. He reasoned that the folding had been occasioned by the curvature of the strata as they subsided, the result being that the lower beds were stretched, while the upper ones were compressed. Dana combatted the theory on the ground that the curvature could not supply either the pressure or the amount of compression required by the facts. Hall, however, never yielded the point and republished in 1882 his original statement of 1857.

One phase of the gravitation theory remains debatable even to-day, since it involves the unknown factor, the capacity of the earth's crust to bear loading. Where great thicknesses of sediment have accumulated gradually in a trough that has deepened as gradually, did the loading occasion the subsidence? Or did subsidence, due to some other cause, provide depth for the loading? How strong is the crust? What load may it support? Consideration of this problem led Dutton to the idea of balance of the earth's crust. He reasoned that a heavy mass would sink to a lower level than a lighter mass; consequently the surface would exhibit depressions (ocean basins) and elevated areas (continents). But erosion is constantly transferring material from the continents to the oceanic margins and thus disturbs the equilibrium. The unloaded continent should rise and the loaded ocean bed should sink. And there should be a subterranean movement from the latter toward the former. This concept became known as the theory of isostasy which played a very important role in the discussions of the subject. Two schools of thought developed: A weak-crust school represented by J. F. Hayford, Wm. Bowie, and R. A. Daly, assumed a condition of almost perfect balance, a yielding to small differences of load by very slow adjustments. The other school recognized some degree of rigidity in the support of unequal loads and sought to estimate it in terms of the weight of masses, such as mountains, which the crust might carry. G. K. Gilbert was its chief exponent. The weak-crust group has seemed to demonstrate almost perfect equilibrium by numerous observations for the intensity of attraction of gravity, which are evaluated by means of elaborate adjustments; but the mathematics are no stronger than the assumptions, which fail to take account of the elasticity of the foundations. Gilbert, through a searching study of the effect of evaporation of the waters of Lake Bonneville and of commensurate masses which appear to be rigidly supported reached the conclusion that:

> Mountains, mountain ranges, and valleys of magnitude equivalent to mountains exist generally in virtue of the rigidity of the earth's crust; continents, plateaus, and oceanic basins exist in virtue of isostatic equilibrium in a crust heterogeneous as to density.

Subsequent research confirmed this estimate and it is widely accepted as a working hypothesis, as Gilbert put it, although still there are many geologists who accept the conclusion that isostasy is nearly perfect.

These researches in isostasy have been intimately related to the problem of the forces that push up mountain ranges, but it must be said that neither the contraction theory of Dana, nor the gravitation theory of Hall, nor the thermal theory of Millarde Reade, nor the hypothesis of subterranean drag and push in a movement to restore isostatic equilibrium, nor any one of many minor suggestions, has been found satisfactory. American geologists were generally agnostic toward the problem of mountain-making forces toward the end of the nineteenth century—and it may be said still are so.

Mineralogy, the oldest branch of geology, received a great deal of attention in America during the nineteenth century. In this as in broader fields James D. Dana was for sixty years an American authority whose "Manual of Mineralogy" was standard. In successive editions he developed the classification of minerals based upon the fact that minerals are chemical compounds, subject to the laws of chemistry, and capable of reactions to changes of pressure and temperature. Though the change in the point of view was gradual it was very profound, full of significance for the future of mineralogy. What had been a purely descriptive study, of interest chiefly to collectors, became analytical research, directed toward better understanding of the nature of minerals and crystals. Dead minerals came to life.

Crystals had long been examined under the microscope, especially with reference to what could be seen in the thin edges of chips, but it was not until the eighteen-seventies that the art of grinding thin, translucent sections was developed successfully. It became the basis of that study which is now known as petrography. An extremely fertile field, richly sown with facts relating to the characteristics of minerals and their family connections, was opened to examination. The harvest was almost embarrassingly abundant. Hosts of new species appeared. Naming became the fashion. The resulting confusion extended to the description and classification of rocks. Late in the century a group of petrographers, consisting of Whitman Cross, Joseph Iddings, L. V. Pirsson and Henry Washington, undertook to frame a quantitative classification of igneous rocks, based on chemical and quantitative, mineralogic characters. The basic postulate was that the nature of the rock was determined by the chemical composition of the melt from which the minerals had crystallized. The research therefore directed attention toward the study of molten bodies, magmas, beneath the outer crust. It was not published, however, until 1903.

Petrography is a descriptive science; the related study, which investigates the genesis of rocks, is called petrology. Its dynamic nature may be indicated by a quotation from Rosenbusch, founder of petrography, who wrote (1876): "A rock becomes alive to me only when I have grasped its relations to our planet and its history."

He glimpsed a future in which, through study of rocks in the making, we may approach an understanding of the processes that are active in the mass of the earth, under the great pressures, at the high temperatures, through the enormous forces therein existing. In so doing he was at least half a century ahead of others. The recognition of petrology as a promising branch of geology was delayed till about 1890 and its development has been slow. It could not be otherwise. Physics, which must lead in dynamics, was stopped at the atom. It was impossible to penetrate the realm of subterranean forces until that citadel was reduced.

The idea that minerals can adapt themselves to changes of temperature and pressure is expressed in the term metamorphism or its equivalent, alteration. Studies of metamorphosed or altered rocks were purely descriptive, as in other branches of mineralogy, but with the development of optical methods of study and especially of the examination of thin sections under the microscope, the investigation of reconstructed, recrystallized, *i.e.,* metamorphic rocks, was pursued as analytical research, having for its aim an understanding of the effects of heat, confining pressure, and an unbalanced pressure during the process of recrystallization. The microscope confirmed what had long been known on a larger scale, namely, that certain laminated or fibrous rocks, the gneisses and schists, had been forcibly elongated and their minerals rearranged in parallelism, partly by rotation of the original crystals, partly by the growth of new ones. The effects were in part mechanical, in part physicochemical, in varying degrees, and involved shearing of an exceedingly intimate character, and also flow of the solid rock under extreme conditions. Prominent among the many geologists who pursued these difficult studies were the Finnish geologist, Sederholm, and C. R. Van Hise, of Wisconsin. The latter, as a result of investigations begun with R. D. Irving in 1882, in the Lake Superior region, published in 1904 a very comprehensive treatise on metamorphism designed to cover the entire subject of rock alteration. In the then state of knowledge of physics and petrology it was an exhaustive treatise, but in consequence of the revolution in atomic physics and its bearing on problems relating to crystallization from magmas and recrystallization of solid rocks it has now become a reference work, of classical interest chiefly. In that respect it has shared the fate of nearly all the compendiums of geological learning of the last century.

In the study of historical geology a knowledge of metamorphism has made it possible to read the records of that remoter past, which is represented by the so-called Archean rocks. The vast areas of these crystallines in North America and Europe, which were known to Dana, were described by him as continental nuclei, as masses formed at that stage of the earth's development when continents began to grow, possibly before there were any sedimentary rocks. But through researches in metamorphism it became possible to distinguish metamorphosed sediments from rocks of igneous origin and to determine the sequence of their relations. Gradually the ancient record has been read, not only in America, but in all continents, and much is now known of the geography and terrestrial activities of those long past eras. The imaginary stages of earth history, the creation of lands and seas, the catastrophies from which they sprang or in which they, Atlantis-like, disappeared were found to be mythical as the gods of Scandinavia and have been replaced by the normal events of terrestrial change.

Thus the study of the metamorphic rocks widens our understanding in two directions. It throws a beam of light into vistas of the past of which we never dreamed and it uncovers the processes of gradual change in the realms of force far beneath our feet.

The nineteenth century bequeathed to geology a rich inheritance of facts. In every branch, in historical, paleontological, structural, mineralogical, economic, in every subject, the mass of observations was so great that no scholar could embrace it all. Leaders emerged as specialists, not like Dana as all-round geologists. Special societies were contemplated and eventually organized in order that students of one branch or another might have opportunity to discuss with fellows who would understand, rather than to talk to experts in other fields who could not be expected to. And yet an individual advancing in his preferred line of research often found need of support from a colleague or from a group of colleagues proceeding on other lines and mutual exchange of ideas characterized the relations of the truly broad-minded. The open mind was encouraged by such outstanding scientists as Chamberlin and Gilbert, authors of the method of multiple hypotheses, and cooperation was vigorously promoted by the Geological Society of America, the U. S. Geological Survey and the geological faculties of Harvard, Yale, Wisconsin, Chicago and other leading universities. American geology entered the twentieth century strongly manned and rich in material for study. The condition was an exceedingly healthy one, in marked contrast to that

which had prevailed when paucity of information and tenacity of individual opinion retarded progress.

Nevertheless, the science was very weak in theory. Chamberlin when asked on one occasion what occupied his thought replied in miner's phrase: "Prospecting old drifts to see what, if anything, of value is left in them." He referred specifically to the Laplacian hypothesis of the genesis of the solar system (which he and Moulton proved fallacious) and its consequences in geology, the once molten, cooling globe; the once steaming, now congenial atmosphere, the once potent, now dying earth. These ideas had become suspect. Advanced students entertained the thought that the planet was much older than had been estimated, that its vast energies were still very effective, and that the changes they had wrought in its crust during the later geological periods were so great that they could not have been worked by gravity and residual heat. Yet no other forces were known and the framing of new hypotheses to replace the old proceeded doubtfully. In this day, 1942, it is known that those doubts were fully justified; however, thanks to Madame Curie the inexhaustible energies of the atoms of the globe, that is to say the energies of its entire mass, are potentially available to geological speculation. It is no longer a question of power, but one of its distribution and of the mechanisms through which heat, gravity and atomic forces work.

PHYSICS IN INDUSTRY[1]

By Dr. E. U. CONDON

ASSOCIATE DIRECTOR, RESEARCH LABORATORIES, WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

TO-DAY the nation's industries are working together as never before to do their part in the battle for freedom. It is fitting at such a time that we look over that part of civilized life for whose cultivation we as physicists are responsible, that we try to see how our science has been developing and in what direction we may cause it to grow in the future. We want to see clearly the job ahead so we can set about doing it earnestly and cheerfully; for we believe that, with effort, we can determine the future in peace as in war.

Although we can trace contributions to physics in America as far back as, say, Benjamin Franklin and his kite, the reasonably wide-spread organized research in physics that is now such an important feature of American academic and industrial life is a product of the last twenty-five years. Our professional group, the American Physical Society, is not yet fifty years old. For the first twenty years or so of its existence, very little was reported by its members which has affected the later development of our science in a basic way. The period was one of thoroughly sound beginnings marked by a few really outstanding contributions: Rowland discovered the magnetic effect of moving electric charge, and he perfected the diffraction grating for spectroscopy. Hall discovered the Hall effect, which is to-day a valuable tool in studying electrical conduction in metals and crystals. Michelson and Morley discovered the phenomena which laid the groundwork for the theory of relativity. Somewhat later Millikan measured the charge on the electron and the Planck constant.

It was a period in which very few of our physicists had the opportunity to contribute much to the advancement of science. Most of them were concerned with teaching, and the great industrial laboratories as we know them to-day simply did not exist.

A great change set in just after the first World War, although it is hard to see that that had much to do with it directly. Indirectly it did, for war acts as a stimulus to cooperative effort. The National Research Council was organized and soon after the war the Rockefeller Foundation established the National Research Council fellowships in physics, chemistry and mathematics. By this means some fifty young doctors of philosophy were each year enabled to continue their development as research men to such a degree of self-reliance that most of them could shoulder other burdens without losing their ability to carry on in research. I believe that these fellowships alone, supported at a cost that was absolutely trifling, have done more for the development of American research science than any other single thing. The fellowships reacted not only on the fellows but on the institutions and the faculties at the universities where the fellows worked.

In the 1920's research in fundamental physics expanded by leaps and bounds. The momentum carried by x-ray quanta was demonstrated by Arthur Compton. Davisson and Germer discovered electron diffraction; investigation of cosmic rays was inaugurated; atomic and molecular spectra were analyzed; and a group of young American theoretical physicists participated vigorously in the development of quantum mechanics.

It was also a period of rapid expansion of industrial physics in the electronic industries. From the birth

[1] Essential substance of an address delivered at the opening of the Charles Benedict Stuart Laboratory of Applied Physics, Purdue University.

of radio broadcasting in Pittsburgh in 1920 there was steady progress in the development of useful applications for phenomena associated with electric discharge in gases. The applied science of electronics was born to serve as a strong bond between physics and electrical engineering.

However, it was rather characteristic of that period that industry and physics were not closely associated. Academic physicists were a little inclined to be mistrustful of industry. In some vague way it was felt by many that the interests of engineering and of physics were best served by keeping them far apart after the engineering student had finished his sophomore course in general physics! Many a bright young man, turned physics instructor, felt he was casting pearls before swine when he had to expound the beauties of his subject to the sophomore engineers. Oddly enough, the engineering students could detect this air of condescension in their physics instructors and did not react to it with humility. I am often surprised at the vehemence with which leading engineers whom I meet will denounce the physicists who taught them in college. It was a most unhealthy situation. Happily it is now almost completely changed.

Then came the 1930's, largely a shameful decade in which people lived in insecurity, with much unemployment, little hope of professional advancement and in which there was a totally inadequate development of our natural resources in scientific talent and inventiveness. Like fools we watched while our present enemies bent every effort toward the mobilization of their universities and their industries to prepare the means that would crush us as a free people. In 1934 when Hitler started to rearm, many of our physicists were unemployed, and our young people could see little opportunity for a career in science. By 1936 the armament program had progressed so far in Germany as to require speed-up in the universities, such as we now have, in an attempt to supply the vast numbers of technical men which modern warfare requires. But we slept on, seeing in this not a marvelously coordinated effort to conquer us, but simply viewing it as a distant anti-intellectual attack on their universities. As late as 1940, even in 1941, there were those who argued against taking steps to resist these murderers of Lidice—because to do so would call for disturbing our way of life, and upsetting the calm, detached pursuit of knowledge in our universities!

On top of all this blindness to the international scene, we had to hear attacks on the scientific method as anti-social. Economic and social ills of society culminating in the depression were somehow blamed on science—as if all our troubles arose from too much of that calm analysis of carefully checked observations that is characteristic of scientific method! Somehow it just couldn't be admitted that there were some unsolved problems in applied social science. Somehow the fault lay with the physicists, for having taught us too well to understand the forms of matter and energy and how to use this knowledge to improve man's physical conditions of life.

Silly as such talk sounds now, it had quite a following in the 1930's. Support of scientific research was unduly curtailed except toward the very end of the decade. This situation might have been much worse if it were not for the fact that those physicists who had jobs, in spite of depression conditions, were having such a gloriously good time.

Heavy hydrogen was discovered, the neutron, the positron, artificial disintegration of the elements, artificial radioactivity, isotopic masses were measured with precision, new means for producing high voltage were developed, and finally there came the application of the new knowledge, while not yet five years old, to give medicine and biochemistry new tools of investigation that were soon to make vast changes in their approach to basic problems. With all this going on, is it any wonder that physicists did not find time even to answer the charge that they were responsible for the depression!

To be sure, some of them would have felt better to have had decent jobs; others would have liked, or at least their wives wished for, a little raise. And lots of fine young minds who would be most welcome in the profession to-day looked elsewhere for work, seeing how limited were the opportunities in science.

But the outlook was not entirely as dark as I have painted it. Toward the end of the 1930's there developed in America a new realization of the fruitfulness of bringing the newest results of physics into industry. Industrial research, already strongly established in the chemical field, began to expand in the direction of applied physics. The more progressive engineering schools established courses in applied physics. More physicists began to find their places in industry. Physicists began to see that their science, far from being restricted or polluted by an association with technical processes, could derive a new stimulus and a new significance that it could never possess so long as it was the private intellectual pursuit of a cloistered few.

For a time it looked as if there might be a separatist's movement whereby the industrial physicists would have professional societies of their own and would have little to do with the academic or "pure" physicists. Fortunately all such tendencies have been eliminated.

This war has completed the job of bringing all American physicists to a clear understanding of how much their science can contribute to the welfare of the

people. At the moment their energies are devoted to applying their knowledge to winning the victory with a minimum of human suffering and material waste. Many university men are learning for the first time that there is a thrill and a deep satisfaction not only in discovering a new principle in science, but also in putting principles into application in new ways. When this war is over they will not forget this experience. Returning to the pure science laboratories in the universities they will have a sympathetic understanding of the problems of industry which will broaden and enrich the relationships of physics and engineering. I think they will even be more friendly and more tolerant of the sophomore engineers.

We must resolve not to neglect the cultivation of the basic science which we hope some day to apply. More and more, industry in America is recognizing the debt it owes to fundamental science—a debt it can hope to repay by fostering more basic research in its own research laboratories and by working in close cooperation with the universities.

I feel sure that those who are entrusted with furthering scientific research at colleges see this problem of applied physics in all its broad implications. They recognize, as we do in industry, that all physics is applied physics—so-called pure physics being simply that part whose application is to satisfy the curiosity of the physicists.

SCIENTIFIC EVENTS

RECENT DEATHS

DR. JACOB GOULD SCHURMAN, formerly professor of philosophy and president of Cornell University, later Ambassador to Germany, died on August 12, at the age of eighty-eight years.

MILTON THEODORE THOMPSON, retired civil and electrical engineer, who had assisted in the construction of some of the largest power dams, died on August 9. He was seventy-two years old.

DR. MARTIN EZRA KLECKNER, professor emeritus of chemistry and geology in Heidelberg College, died on July 13, at the age of eighty-one years. He had been connected with the college since 1886 when he was appointed an assistant.

ADDISON L. GREEN, since 1926 chairman of the board of trustees of the American School of Prehistoric Research, Yale University, died on June 24.

ARTHUR LAIDLAW SELBY, until 1926 when he retired with the title of emeritus professor of physics of University College, Cardiff, died on July 22, at the age of eighty-one years.

THE NUTRITION FOUNDATION

IT is announced by George A. Sloan, president of the Nutrition Foundation, that at a meeting of the executive committee held on August 12, there had been received new subscriptions amounting to $75,000 from six new member organizations. These, with subscriptions previously announced, bring the fund for the support of nutrition research to the sum of $923,500.

At the same time, Dr. Charles Glen King, scientific director of the foundation, announced the founding of *Nutrition Reviews,* a monthly journal of interpreted progress in the science of nutrition. Its purpose, he explained, is "to bridge the gap between basic research findings and their acceptance with confidence, on the part of those who deal with the public, to enable them to keep abreast of current progress and to have available an unbiased, authoritative review of current research literature."

Dr. Fredrick J. Stare, assistant professor of nutrition and biochemistry at Harvard University, was named editor of the new publication. It will be supervised by an editorial committee representing nutrition research and medicine. Members of the editorial advisory committee are:

Reginald M. Atwater, American Public Health Association.
Samuel W. Clausen, University of Rochester.
George R. Cowgill, Yale University.
Conrad A. Elvehjem, University of Wisconsin.
J. Murray Luck, Stanford University.
James S. McLester, University of Alabama.
Henry C. Sherman, Columbia University.
Russell M. Wilder, University of Minnesota.
John B. Youmans, Vanderbilt University.

The following assistant editors have been appointed:

Esther Batchelder, Bureau of Home Economics, Washington, D. C.
Franklin C. Bing, Council on Foods and Nutrition, American Medical Association.
R. Adams Dutcher, Pennsylvania State College.
Robert S. Goodhart, Nutrition Division, Office of Defense, Health and Welfare.
Carl V. Moore, Washington University.
Elmer J. Stotz, Harvard University.

A patent policy, adopted on the recommendation of Dr. Karl T. Compton, chairman of the board, provides for making research findings available to industry with full protection of the public's interest. Mr. Sloan's statement of the patent policy of the foundation follows:

If patentable inventions should be made in the course of research work supported by the Nutrition Foundation,

the Foundation recognizes its duty to arrange for these inventions to be handled in such manner as to bring the maximum benefit to the public. Such arrangements, provided the customs and policies of the sponsoring institution permit, and the research workers are agreeable, should include consideration of the following points: the inventions should be made available to industry and to the public on a reasonable basis; the patent should be used to enforce quality and safety, if necessary; conditions likely to exclude any qualified manufacturer from use of the invention, or likely to lead to litigation, should be avoided in so far as is reasonably possible. The primary objective of such patents as may be taken out under Foundation sponsorship is not to make money, but to enable the situation to be handled and, if necessary, controlled by the procedures duly constituted for such handling, in the public interest.

The following were elected members of the board of trustees:

L. A. Warren, president of Safeway Stores, Inc.

Charles P. McCormick, president of McCormick and Company.

Karl J. Monrad, vice-president of Chr. Hansen's Laboratory, Inc.

H. R. Drackett, president of The Drackett Company.

Frank Gerber, president of Gerber Products Company.

E. B. Cosgrove, president of the Minnesota Valley Canning Company.

E. B. Pickett, chief chemist in charge of research for the Beech-Nut Packing Company, was appointed a member of the Food Industries Advisory Committee.

The new subscriptions represent membership of the following: *Founder Member,* Safeway Stores, Inc., Oakland, Calif.; *Sustaining Members:* Gerber Products Company, Fremont, Mich.; Chr. Hansen's Laboratory, Inc., Little Falls, N. Y.; McCormick and Company, Baltimore, Md.; Minnesota Valley Canning Company, Le Sueur, Minn., and The Drackett Company, Cincinnati, Ohio.

The foundation is now supporting thirty-six nutrition research studies in twenty-two of the leading universities, and additional study awards will be made this fall. These studies are divided equally among three kinds of projects: (1) those having a direct relationship to the war emergency; (2) those having a direct relationship to public health; and (3) those that primarily advance the frontiers of the science of nutrition.

THE INDUSTRIAL NUTRITION ADVISORY SERVICE

The U. S. Public Health Service, in cooperation with the Office of Defense Health and Welfare Services, is carrying out a national industrial nutrition program.

An industrial nutrition advisory service has been organized under the direction of Dr. W. H. Sebrell, director, Division of Chemotherapy, U. S. Public Health Service, and deputy assistant administrator, Office of Defense Health and Welfare Services, and M. L. Wilson, assistant administrator, Office of Defense Health and Welfare Services.

This service will provide practical recommendations to both government owned plants and private industries to meet specific industrial nutrition problems which may affect production by increasing absences and accidents. Requests which have already been received from private industries indicate their interest in the possibility of cutting down lost man-hours of production and accidents through solving some of the problems of industrial nutrition.

Dr. Robert S. Goodhart, of New York City, who recently received his appointment in the U. S. Public Health Service, will direct the nutrition advisory service to industry. As a member of the National Research Council Committee on Nutrition in Industry, Dr. Goodhart has visited industrial plants in many parts of the country.

Assisting Dr. Sebrell and Dr. Goodhart will be Dr. Mark Graubard, the biochemist, formerly of Columbia and Clark Universities, who has studied food habits and customs of peoples in many parts of the world, and Ernestine Perry, formerly of Springfield, Mass., who directed one of the country's first industrial nutrition community campaigns and is author of a folder and book on food for war workers.

There are committees in forty-eight states and the District of Columbia, 2,500 county committees and community nutrition committees already functioning throughout the country with the advisory service of regional nutrition representatives of the Office of Defense Health and Welfare Services.

THE NATIONAL ROSTER OF SCIENTIFIC AND PROFESSIONAL PERSONNEL

Dr. J. S. Nicholas, of Yale University, National Research Council representative on the National Roster of Scientific and Professional Personnel, sends to Science the following details in regard to the work of the roster:

The science section was initiated by utilizing the mailing lists of all cooperating scientific societies. To these have been added names secured from graduate schools of colleges and universities, including, in some fields, undergraduates. Individual departments of study, particularly in physics and engineering, have also been requested to submit names for questionnaire circularization. It was recognized at the outset that such lists are not complete, but that their assembly formed the quickest possible mechanism of accumulating an immediate reservoir of information necessary for emergency allocation.

Additional information concerning scientifically

trained personnel is now being added from the occupational questionnaires which are being filled out for draft boards as the result of the recent national registrations. The roster is circularizing the individuals whose names appear in specialized brackets just as quickly as possible. It also plans to re-circularize the society memberships in order to bring its data up to the minute and to evaluate the needs and demands in the different fields.

On August 1 registration was as follows:

QUESTIONNAIRES

Field	Number mailed	Number returned
Animal sciences	14,135	7,678
Includes: Veterinary science, Fish and wild life, Animal husbandry, Dairy science		
Botany	2,194	1,435
Forestry	5,380	4,077
Genetics	2,083	1,070
Plant pathology	4,986	3,048
Zoology	7,891	4,622
Anatomy	831	651
Bacteriology	3,736	2,213
Nutrition	499	286
Pharmacology	345	217
Physiology	1,038	676
Tropical medicine	910	460
Chemistry	100,459	68,639
Geology	7,161	3,832
Geophysics	4,346	2,043
Mathematics	12,026	6,885
Physics	13,678	9,760
Physicians		149,720
Veterinarians		11,209
Dentists		62,423

The percentage of the number of questionnaires returned varies in each of the fields. There is duplication and overlapping between the memberships of societies, which accounts for some of the apparently incomplete records. This, however, does not free scientifically trained personnel from the responsible obligation of registering for our war needs in some way on every questionnaire sent out.

The problem of answering questionnaires is always an irritating one. So many questionnaires seem to be unnecessary that we lose sight of the fact that any set of questions unanswered may include the one necessary one. Many society members have apparently failed to recognize this fact.

If the roster is to be of fullest service to the sciences as well as to the nation it must have cooperation. If the status of any scientific man has changed, or if he has re-evaluated his possible service—such information should be sent to the roster. Thousands of scientists have been certified already for essential work in the war program. More are being allocated as the facilities of the roster are increased and its utility appreciated. The successful employment of the roster depends ultimately upon the full cooperation of every scientist in the country.

THE BUFFALO MEETING OF THE AMERICAN CHEMICAL SOCIETY

AT the meeting of the Division of Physical and Inorganic Chemistry of the American Chemical Society, which meets in Buffalo from September 7 to 11, Dr. John Lawrence Oncley, associate in physical chemistry at the Harvard Medical School and 1942 winner of the $1,000 American Chemical Society Prize in Pure Chemistry, will deliver an address at an afternoon session on Thursday, September 10, illustrating the application of physico-chemical methods to biochemical problems.

Dr. Robert Simha, of the Polytechnic Institute of Brooklyn; Dr. William D. Harkins, of the University of Chicago; Dr. Nelson W. Taylor, of Pennsylvania State College, and Dr. Elmer O. Kraemer, of the Biochemical Research Foundation, Newark, Del., will speak at a symposium on "Flow under Abnormal Conditions," on September 8. The Society of Rheology will join in the symposium, which will deal with the nature of flow in plastic substances such as glass and rubber, in contrast to the normal "viscous" flow of liquids like water. Professor Hermann Mark, of the Polytechnic Institute of Brooklyn, will preside.

A symposium on "Kinetics Using Tracer Isotopes" is planned for the afternoon of September 8. It has been organized by Professor W. F. Libby, of the University of California, and will constitute a review of recent progress in the use of "marked" or "labeled" atoms to throw light on the mechanism of chemical reactions. Papers will be presented by Professor Libby; Dr. Glen T. Seaborg, of the University of California; Dr. Edwin O. Wiig, of the University of Rochester; Dr. H. C. Anderson and R. D. Fowler, of the Johns Hopkins University; Dr. Victor K. LaMer and Frank Brescia, of Columbia University and the College of the City of New York; Dr. A. R. Olson, of the University of California, and Dr. A. Farkas, of the Union Oil Company, Wilmington, Calif.

A third symposium has been arranged for September 10 by Professor Donald H. Andrews, of the Johns Hopkins University, on "Low Temperature Phenomena," dealing with the behavior of substances of low temperature, which, it is pointed out, has been of great importance in the study of the properties of matter in bulk. In addition to Professor Andrews, the speakers will be Dr. A. D. Misener, of the University of Toronto; Dr. E. R. Blanchard, of the Johns Hopkins University; Dr. C. C. Stephenson and H. E. Adams, of the Massachusetts Institute of Technology; Dr. J. G. Aston and R. M. Kennedy, of Penn-

sylvania State College, and Dr. Kenneth S. Pitzer and Donald W. Scott, of the University of California.

Several sessions in physical chemistry will be held, discussions ranging all the way from theoretical papers on atomic and molecular structures to applications to biology and pharmacology. Research reports from various fields in inorganic chemistry will be presented at other sessions.

Dr. Harold J. Barrett, of the Electrochemical Division of E. I. du Pont de Nemours and Company, will speak on "Unique Chemicals Derived from Salt" at a dinner meeting of the division.

Numerous members of the division are intimately associated with the war effort in special government research work and in the manufacturing problems of essential industries.

SCIENTIFIC NOTES AND NEWS

The American Laryngological Association has conferred its Newcomb Award on Dr. Francis R. Packard, formerly professor of otology of the Postgraduate School of the University of Pennsylvania, in recognition of "his scientific attainment in rhinology and laryngology and as a mark of esteem and appreciation for services to the association."

Rutgers University conferred the honorary degree of doctor of science on Dr. Robert P. Fischelis, secretary and chief chemist of the Board of Pharmacy of the State of New Jersey and chief of the Medical and Health Supply Section, Office of Civilian Supply, War Production Board, at the annual commencement of the College of Pharmacy, for "notable contributions which have greatly strengthened the essential service which the science of pharmacy renders to the health of America."

The degree of doctor of science has been conferred by the University of Wales on Dr. C. R. Austin, professor of metallurgy at the Pennsylvania State College, in recognition of "his outstanding work in metallurgy."

The July number of the *Archives of Pathology* is dedicated to Dr. Eugene L. Opie, emeritus professor of pathology at Cornell University Medical College, by his former associates on the occasion of his retirement. Dr. Peyton Rous contributes the opening article and the number includes contributions from a number of distinguished investigators.

Colleagues of Dr. Caleb W. G. Rohrer, Baltimore, chief of the Pasteur Division of the Maryland State Department of Health, on June 1 presented to him a silver vase to mark his completion of forty years' service with the department. Dr. Charles H. Halliday, Baltimore, a former student of Dr. Rohrer's and assistant director of the department, gave the presentation address.

Vice-President Henry A. Wallace has been elected an honorary member of the National Association of Science Writers, in recognition of "his interest in the popularization of science and his research contributions in the field of genetics."

Officers for the coming year have been elected by the Smith Chapter of the Society of the Sigma Xi as follows: *President,* Dr. Elizabeth Sanders Hobbs, zoology; *President-elect,* Dr. Arthur Taber Jones, physics; *Secretary,* Miss Helen Stobbe, geology, and *Treasurer,* Dr. Elinor VanDorn Smith, bacteriology.

Dr. J. W. H. Eyre, emeritus professor of bacteriology of the University of London, has been elected president of the Royal Institute of Public Health and Hygiene in succession to the late Sir Thomas Oliver.

Dr. William Pratt Graham, since 1937 chancellor of Syracuse University, previously professor of electrical engineering and dean of the College of Applied Science, will be succeeded as chancellor by Dr. William Pearson Tolley, since 1931 president of Allegheny College.

Dr. Harry R. Wellman, professor of agricultural economics at the University of California at Berkeley, has been appointed director of the Giannini Foundation.

Dr. Louis E. Hawkins has been appointed vice-director of the Oklahoma Agricultural Experiment Station to succeed Dr. Lippert S. Ellis. Dr. Hawkins has been agricultural commissioner of the Kansas City Chamber of Commerce for the past seven years, and was previously a member of the department of animal husbandry at the Oklahoma station.

Dr. Charles L. Fluke, professor of entomology at the University of Wisconsin, has been named chairman of the department of economic entomology. He succeeds H. F. Wilson, who has served as department chairman since 1915.

The following promotions have been made in the department of obstetrics and gynecology at the University of Chicago: Dr. M. Edward Davis and Dr. William J. Dieckmann, associate professors, have been promoted to professorships and the latter has been made chairman of the department. Dr. H. Close Hesseltine, assistant professor, has become an associate professor.

Current Science, Bangalore, India, reports that Dr. N. Kesava Panikkar, Empire Overseas Research

Scholar of the Royal Commission for the Exhibition of 1851, has been appointed professor of zoology in the Maharaja's College of Science, Trivandrum. Dr. Panikkar is a graduate of Madras University and a member of the staff of the Madras Christian College. He was awarded the Exhibition Scholarship in 1938 for research in marine biology. While in England he was engaged in the study of the mechanism of physiological adaptation in animals. Information has been received that the Royal Society has provided a special grant for his researches at Travancore.

Dr. A. J. Heinicke, head of the department of pomology of Cornell University and of the Experiment Station, has been appointed director of the New York State Station at Geneva, N. Y., to succeed Director P. J. Parrott, who will retire on September 1.

Dr. W. S. Gordon has been appointed director of the field station of the British Agricultural Research Council at Compton, near Newberry, Berkshire, in succession to the late G. W. Dunkin. Dr. Gordon has been senior bacteriologist on the staff of the Animal Diseases Research Association at Moredun Institute, Gilmerton, Midlothian, since 1930.

According to the *Journal* of the American Medical Association, Dr. David D. Rutstein, chief of the cardiac bureau of the New York State Department of Health, Albany, has been appointed a member of the staff of the Medical Division, Office of Civilian Defense, Washington, D. C., as medical gas officer to organize instruction for physicians of the Eastern States in the medical aspects of chemical warfare.

Dr. Haskell B. Curry, professor of mathematics at the Pennsylvania State College, has leave of absence to enable him to serve as associate mathematician at the Frankford Arsenal for the duration of the war.

Dr. James M. Cork, professor of physics at the University of Michigan, has leave of absence for the summer to assist in adapting the cyclotron at the California Institute of Technology to war purposes.

Dr. Anton J. Carlson, Frank P. Hixon distinguished service professor of physiology emeritus of the University of Chicago, gave a Mayo Foundation Lecture at Rochester, Minn., on July 2. The title of his lecture was "The Newer Knowledge of Nutrition—How Much of It Is Knowledge?"

Dr. Alexander Silverman, head of the department of chemistry in the University of Pittsburgh, addressed the New England Chemistry Teachers Association at Durham, N. H., on August 14. He spoke on "Glass and the War."

Due to wartime difficulties in arranging for the transportation of delegates, the first Inter-American Congress of Philosophy has been postponed. The forty-second annual meeting of the Eastern Division will therefore be held at Yale University from December 28 to 30.

The fiftieth anniversary meeting of the American Psychological Association, scheduled for Boston and Cambridge for the first week in September, has been cancelled in cooperation with the request from the Office of Defense Transportation. A "skeleton" meeting will be held at the Hotel Pennsylvania in New York City at 1:30 P.M. on September 3. The meeting will be attended by members of council, chairmen of committees and such members as are resident in the New York area. The program of scientific papers has been cancelled and the business meeting will be devoted to routine matters and to the problem of the utilization of psychologists in the war effort.

Owing to war emergency work, it has been decided by the executive committee of the Association of Official Agricultural Chemists that the annual meeting, planned for October 27, 28 and 29, will not be held.

The twenty-seventh annual meeting of the Optical Society of America will be held at the Hotel Pennsylvania in New York City on October 30 and 31. Plans for a meeting of the society last February were cancelled because of the war emergency. This action was criticized by those who believe that a meeting of the Optical Society provides an opportunity, outside the scheduled program, for discussions and conferences that can otherwise be arranged only with considerable difficulty. It has been argued that the holding of regular meetings actually minimizes the amount of necessary travel. This belief seems to be sufficiently general to insure a well-attended meeting in October, especially at so central a point as New York City. The date of this meeting has been selected to coincide with meetings of the American Mathematical Society and the Society of Rheology, and to follow immediately after the meetings of the Society of Motion Picture Engineers. A symposium on "Optical Instruments" has been arranged for Friday morning and a symposium of invited papers on "Mathematics in the Field of Optics" in the afternoon. A joint luncheon with the American Mathematical Society and the Society of Rheology will be given on that day and the annual dinner will take place in the evening.

Chemical and Engineering News states that the Illinois Mineral Industries Conference, which planned to meet in Urbana, Ill., on October 30 and 31, has been cancelled, according to an announcement by M. M. Leighton, chief of the Illinois State Geological Survey. The sponsoring groups—the Illinois Mineral Industries Committee, the Engineering Experiment

Station of the University of Illinois and the State Geological Survey—have agreed to lend their combined support to the Regional Conference of the American Institute of Mining and Metallurgical Engineers which meets in St. Louis on October 1 and 2. The St. Louis meeting will stress problems of the mineral industries of the Mississippi Valley area, with particular reference to war needs, and the purpose of the Illinois conference, as originally planned, will be adequately met.

THE Biological Laboratory at Cold Spring Harbor, N. Y., recently acquired, as the gift of Mrs. Henry W. de Forest, two tracts of land of about fifteen acres adjacent to the laboratory property. One tract contains a building suitable for living quarters; the other includes the long stretch of beach known locally as the "Sand Spit," which has been used extensively as a collecting ground.

THE Faculty of Medical Science (pre-clinical studies), King's College, London, will return to London in September. The faculties of arts, natural science, engineering and theology will remain in Bristol.

ACCORDING to *Nature,* the following telegram was received by the Linnean Society of London from the Moscow Naturalists' Society on July 11: "Linnean Society, London. Council of Moscow Naturalists of which Charles Darwin was honorary member has been instructed by its members assembled at meeting in commemoration of centenary of appearance of his Origin of Species to convey their ardent greetings to Linnean Society. In midst this great ordeal which has fallen to lot of democratic countries and of science Moscow Naturalists' Society oldest scientific society in Soviet Union pays reverent tribute to memory great scientist and humanist and firmly believes in early victory of our countries over Hitler tyranny." Academician Alexander Fersman, Professor Serge Ogneff, Professor Vera Varsanofieva (vice-presidents), Professor Serge Lipshitz (Secretary). The following telegram was sent by the Linnean Society of London in reply on July 16: "Moscow Naturalists' Society, Moscow. The Linnean Society of London heartily reciprocates your friendly greetings and joins in tribute to memory of Charles Darwin most illustrious member on our roll. The magnificent resistance of the Russian people to Nazi aggression has aroused deepest admiration in our country. We share your confidence in early victory of the United Nations and are with you to the end." E. S. Russell (President).

THE report of the council of the Ray Society states, according to *Nature,* that, with the consent of the members, the annual general meeting has again not been held, and the present officers and council will continue to act for the current year. The accounts show that the reduction in the amount received from subscriptions has again been less than was anticipated and the sales of the society's publications have been well maintained. A volume on "The Larvae of Decapod Crustacea," by Dr. Robert Gurney, will shortly be issued to subscribers for 1941. A work on the British Mysidae (Opossum shrimps) by Professor W. M. Tattersall is in preparation and is intended to form the issue for 1942. Owing to shortage of materials, the publications will, for the present, be issued in paper covers, but it is hoped later to supply covers for binding uniform with the volumes already published. The council reminds members that, under present conditions, considerable delay in the publication of the annual volumes can not be avoided. It is mentioned that at least one author has lost, by enemy action, all the notes and manuscripts prepared for a work to be offered to the society.

DISCUSSION

THE BLOOD PRESSURE IN THE UMBILICAL VEIN OF THE FOETAL SHEEP

ALL those interested in the subject must have admired the demonstration which has been given by Whitehead[1] of the divergent courses taken by the streams of venous blood entering the foetal heart. There is one point, however, in Whitehead's paper which demands a word of comment, *i.e.,* his suggestion that a high venous pressure is a necessary condition.

It may be helpful to state the venous pressures which have been actually registered in the umbilical vein by us in a research which was interrupted by the onset of war:

Foetal age in days	56	71	89	111	113	118	120	138	141
Pressure in umbilical vein mm Hg.	13	15	11	10	6	11	8	17	10

These values are much lower than those in the pioneer work of Cohnstein and Luntz[2] obtained by methods which involve great interference with umbilical vessels. Our methods involved no more than insertion of a fine hypodermic needle and no constriction of the vessels.

The above figures do not represent the last word, as there is considerable variation among them, the reason for which is the subject of investigation. The immediate point is, however, that none of the figures is above 18 mm Hg. or below 6.

[1] *Anat. Rec.,* 82: 277.

[2] *Pfluger's Archiv.,* 34: 173.

The cine-x-ray photos of Barclay, Franklin and Pritchard[3] suggest that in the sheep only a small fraction of the blood from the umbilical vein reaches the heart through the ductus venosus; the greater part goes through the liver reducing the pressure in the thoracic inferior vena cava to a still lower level.

Indeed the degree of openness of the sphincter of the ductus venosus[4] may be one factor which effects the pressure in the umbilical vein. However, the readings of the pressure have this property: that, in cases of approximately equal age, the lower venosus pressure is always accompanied by the higher pressure in the umbilical artery, which suggests that the explanation of the variation in pressure lies either in the degree of resistance presented by the placental vessels or the distance of the point at which the pressure is measured from the foetus.

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FUSION OF TOP SOIL BY AN ELECTRIC ARC

AN interesting and spectacular event took place during a violent thunderstorm on May 30. The point of location of this event is 4 miles east of Wooster, Ohio, in Green Township, Wayne County, Section 32, along the highway on the farm of S. S. Woods. A stroke of lightning sheared off the field wire at the insulator on a pole supporting a 3-phase, 60-cycle transmission line carrying 22,000 volts. The wire and insulator were blistered by the heat. The bare wire, a No. 2, about 5 sixteenths of an inch in diameter, approximately the diameter of a lead pencil, and supported by poles 150 feet apart, was severed at one end and dropped into a field. For a distance of 45 feet, where the wire touched the ground, the current produced a series of electric arcs. Where these arcs occurred, tremendously high temperatures were produced, such as those in an electric furnace. The loud, somewhat musical sound of variable intensity, characteristic of the electric arc, could be heard at a distance of an eighth of a mile. The brilliant, bluish white light and flames, increasing and decreasing in intensity, produced a weird effect.

The downpour of rain was accompanied by heavy flashes of lightning which produced additional voltage and increased the surges of current along the wire. The wire was severed at 12.18 P.M. and the location of the break was not discovered until 3 P.M. During this interval, nearly 2 and $\frac{3}{4}$ hours, at the point of the arc, the soil was fused into molten material. These masses of molten rock or slag were lying parallel with the wire. They cooled into round, elongate masses, having the shape of the trunk of a tree with branches extending from the main mass. The branches extended into the ground for a distance of not more than a foot. At the point of the greatest arc, the ground is baked for a distance of not more than a foot from the location of the wire. From this area, a mass of fused material, 18 inches long and 4 inches in diameter, with 4 branches more than an inch in diameter, was removed.

It is obvious that the material was in a molten condition, for it is glassy in character and thoroughly vesicular like volcanic scoria or pumice, due to the expansion of enclosed gases, mostly steam. The soil in this locality is glacial in origin, containing clay, sand, humus and occasional rocks. The ground was wet and the soil with its carbon is a good conductor. The high temperature, driving off the water and baking the soil, as well as burning out the carbon, making the ground a poor conductor, would cause the arc to extend parallel with the wire to points beyond, where the ground was wet, producing by this process an elongate structure. The forking of the arc produced the branches extending from the main mass.

There are instances where lightning has struck beach sands and produced round, rod-shaped, fused masses extending into the ground. All the specimens seen by the writer are of small diameter. It may be that the observations described here will help in the interpretation of the structures produced by lightning.

KARL VER STEEG
COLLEGE OF WOOSTER

MODERN FACSIMILE REPRODUCTIONS OF RARE TECHNICAL PUBLICATIONS

NOT infrequently basic technical publications, especially those of the older authors, are unavailable in modern libraries, and it becomes increasingly difficult to secure copies of them. Sometimes the reason is the original small edition, sometimes because the reserve stock was destroyed by accident or otherwise, and sometimes because of the very great demand for what was considered to be an adequate edition at the time the publication was issued. In any case, these rare items are always high-priced. Many of them are rarely or never quoted in catalogues of out-of-print books, yet the actual demand for them is usually insufficient to warrant one in undertaking the expense of issuing facsimile editions.

The case of Rafinesque's very numerous publications is an interesting one, and copies of his original papers are almost never offered by dealers. He was particularly productive in the decade preceding his death in Philadelphia in September, 1840, yet it is now impossible to acquire copies of the majority of

[3] *Brit. Jour. Rad.*, 15: 69.
[4] *Anat. Rec.*, 82: 398.

his publications. Some of these have been reprinted in the past, such as his remarks on Loudon's "Encyclopedia of Plants" (1832), reprinted in the *Journal of Botany* (38: 225–229, 1900), Fitzpatrick's 1908 reprint of the very rare "Annals of Nature" (1820), the *American Midland Naturalist* series of facsimile reprints (1912–13), including the "Neogenyton" (1825), "Monographie des coquilles bivalves et fluviatales de la rivière Ohio" (1820), "Scadiography of Ombelliferous Plants" (1840) and the "Natural Family of Carexides" (1840). Now the exceedingly rare "Autikon Botanikon" (1840), a two-hundred-page volume, nomenclaturally touching all parts of the world, is available, having been lithoprinted in 1942 under the auspices of the Arnold Arboretum. Because of the cheap, often badly discolored or foxed paper on which many of Rafinesque's works were printed, the modern lithoprint reproductions are much clearer and much easier to consult than are the originals, and are thus even to be preferred to the originals, except from the standpoint of a bibliophile.

Reasons for the great scarcity of many of Rafinesque's publications are the original limited editions (for the "Flora Telluriana" he states that only 160 copies were printed and this probably applies to the "Sylva Telluriana" and the "Autikon Botanikon"), the time and method of publication, the fact that his contemporaries looked on his publications as worthless and thus to be ignored, and his death in 1840 at the height of his publishing career. Rafinesque being in debt at the time of his death, his effects were sold at auction to meet the demands of his creditors and the evidence available seems to indicate that much of his unsold stock of publications was utilized as waste paper. In any case, the "Herbarium Rafinesquianum," published in Philadelphia in 1833, is apparently represented in American libraries by the single complete copy at the New York Botanical Garden and a partial copy containing 44 of its 80 pages at the Arnold Arboretum. Of the "Autikon Botanikon" only about ten or twelve copies are known in all libraries, while the "Flora Telluriana" and the "Sylva Telluriana" are apparently nearly as rare as the "Autikon Botanikon."

Attention is called to the fact that in various scattered papers and volumes published by Rafinesque, there are apparently between 1,200 and 1,500 new, validly published, generic names and binomials that are not as yet listed in "Index Kewensis." Thus, although the numerous generic names in the "Autikon Botanikon" were listed in 1929, several hundred new binomials therein published still remain to be incorporated in that standard work, over a hundred years after the names were published, while none of the numerous new names in the "Herbarium Rafinesquianum" and the "Good Book or Amenities of Nature" (1840) is listed in any of our botanical indices.

In view of the fact that many of Rafinesque's pamphlets and books contain the valid publications of a great many new generic names and binomials—and no matter what the status of these entities may be, their actual publication over a hundred years ago places them in a category that must be considered because of the universally accepted homonym rule in botany—it is highly desirable that all these names be listed. Work on this project is being prosecuted, but it is a complicated matter, as it involves a critical examination of all the very numerous technical botanical papers that Rafinesque published, and it is often difficult to locate copies of essential items. But to make Rafinesque's more important works generally available to working botanists everywhere it is highly desirable that certain other works published by him, particularly the "Herbarium Rafinesquianum" (1833), the "Flora Telluriana" (1837–38), the "Sylva Telluriana" (1838) and the "Good Book" (1840), be reissued in modern facsimile editions. The new data published in these works issued over a hundred years ago touch all parts of the world, a fact that has not been realized by many American and practically all European, Asiatic, African, Australian and South American botanists because these Rafinesque publications are even more rare in foreign libraries than they are in those of the United States. Whether or not it may be possible to reproduce some or all of these works will depend in part on support extended to the recent lithoprint facsimile reproduction of the "Autikon Botanikon." Clearly the prices for these modern reproductions must be kept low if these works are to be made generally available. In my judgment the price should not exceed $0.015 per page, which is in very sharp contrast to over $0.30 per page charged for one modern reproduction of a sixteen-page Rafinesque pamphlet and from $0.03 to $0.10 per page for still others; and all these are scientifically of much less importance than is the "Autikon Botanikon."

E. D. Merrill

QUOTATIONS

ARTIFICIAL ANTIBODIES

In vitro synthesis of type specific anti-pneumococcus precipitins and agglutinins has been reported recently by Pauling and Campbell[1] of the Department of Chemistry, California Institute of Technology. Sub-

[1] Linus Pauling and Dan H. Campbell, Science, 95: 440, April 24, 1942.

stances simulating specific antibodies formed outside the animal body were demonstrated thirty years ago by Russian immunologists. Ostromyschlenski and Petroff,[2] for example, incubated a mixture of diphtheria toxin and normal horse serum and obtained an end product with all the therapeutic properties of diphtheria antitoxin. By incubating diphtheria toxin with different protein fractions of normal horse serum, Kryshanowski[3] prepared two artificial diphtheria antitoxins of different therapeutic value. By somewhat different technics, Sdrawosmisslow[4] and Kimmelstiel[5] incubated diphtheria toxin with commercial trypsin and reported the successful test-tube synthesis of a "toxin trypsinate" with the therapeutic properties of an anti-diphtheritic serum. In anticipation of future commercial value, artificial antitoxin made by incubating diphtheria toxin with normal serum plus pancreatin was promptly patented in Germany.[6]

By substituting bacteria for diphtheria toxin, other Soviet investigators[7] successfully synthesized specific agglutinins, bacteriolysins and complement deviating antibodies. This technic was promptly appropriated by German botanists,[8] mainly to avoid the trouble and expense of experimental animals. They incubated plant juices with normal serums and reported the production of artificial precipitins, interchangeable with natural immune precipitins, in their study of biochemical plant relationships. While most of these artificial precipitins were of low titer, Sasse[9] obtained an occasional product with which plant juices could be identified in dilutions as high as 1:6,400. Many unexpected overlapping specificities, however, were reported by other investigators,[10] suggesting plant relationships differing from those suggested by natural immune serums.

The first artificial precipitin for an animal protein was prepared by Kabelik[11] of Czecho-Slovakia. He, however, believed that his synthetic product was not a true antibody but only a biochemical precursor of such an antibody. This conclusion was confirmed by Manwaring,[12] who found that artificial precipitins formed by incubating one part of horse protein with twenty parts of normal rabbit serum usually show zone reactions and other qualitative differences from natural immune precipitins. He concluded that "hybridization" of horse proteins in artificial serum mixtures represents but the initial stage in the natural production of specific antibodies, necessitating the assumption of secondary and tertiary stages in the natural synthesis. It also seemed necessary to assume a continuous, quasi-proliferative process in order to account for the relatively high titer in experimental animals. This proliferative process was conceivably similar to the quasi-proliferation of bacteriophage in symbiosis with bacterial cells.

Subsequent advances in immunochemistry, particularly determination of the chemical nature of haptens and protein molecules, have made possible to-day the formulation of a more definite theory. Pauling,[13] for example, called attention to the fact that globulin molecules are "unfolded" or "uncoiled" under the influence of certain physical or chemical agents much in the way a fern leaf uncoils on approaching maturity. On removal of these conditions the unfolded molecule is again "coiled" to its original surface specificity. Pauling assumes that in the presence of a foreign antigen the refolding is atypical, the globulin molecule coiling around and assuming a surface configuration "complementing the surface regions of the antigen." Dissociated from the adherent antigen, the refolded globulin now functions as a specific antibody or specific receptor for the antigen. Artificial antibodies therefore differ from normal serum globulins only in the way in which the polypeptide chain is refolded or recoiled. This concept is in accord with data currently reported by Wright,[14] who concluded that "horse antibody protein is essentially the same as horse gamma globulin."

In order to test this theory, Pauling and Campbell attempted to prepare antibodies against antigens of known chemical composition. They selected certain antigenic dyes, for example, and type III pneumococcus carbohydrate, bovine gamma globulin being the normal serum protein used in most of their tests. Successful unfolding and refolding of gamma globulin is readily effected by several methods, such as the addition of alkali and slow return to neutrality, the addition and slow removal of urea, or by heating to 65° C. and slowly cooling. Their most satisfactory yield, however, was obtained by incubating the gamma globulin-antigen mixture for several days at 57° C., a process similar to that originally adopted by the Soviet immunochemists.

In a typical experiment, 1 per cent. type III pneumococcus polysaccharide was added to a 1 per cent. solution of bovine gamma globulin and the resulting mixture held at 57° C. for fourteen days. The mixture

[2] Ostromyschlenski and Petroff, *Russ. Gesellsch. f. physical. Chem.*, 47: 263, 1915.
[3] W. N. Kryshanowski, *Centralbl. f. Bakt.*, 110: 1, 1929.
[4] W. H. Sdrawosmisslow and N. E. Kastromin, *Ztschr. f. Immunitätsforsch.*, 54: 1, 1927.
[5] D. Kimmelstiel, *Ztschr. f. Immunitätsforsch.*, 62: 245, 1929.
[6] Patent No. 293055, class 30 h. group 6.
[7] W. M. Sdravomysloff and N. Kistromine, *Bull. Inst. Pasteur*, 21: 941, 1923. N. I. Bashkirzev, *Ztschr. f. Urol.*, 23: 92, 1929.
[8] C. Mez and H. Ziegenspeck, *Botanisches Arch.*, 12: 163, 1925.
[9] F. Sasse, *Beitr. z. biol. Pflanzen*, 16: 351, 1928.
[10] E. Nahmacher, *Beitr. z. biol. Pflanzen*, 17: 1, 1929.
[11] J. Kabelik, *Biologicke liste* (Prague), 1927, p. 31.
[12] W. H. Manwaring, *Jour. Immunol.*, 19: 155, August, 1930.
[13] L. Pauling, *Jour. Am. Chem. Soc.*, 62: 2643, 1940.
[14] G. G. Wright, *Jour. Infect. Dis.*, 70: 103, March-April, 1942.

was then freed from pneumopolysaccharide by a precipitation or salting out method. The resulting free modified gamma globulin ("purified antibody") was found to precipitate type III pneumopolysaccharide *in vitro* but gave negative reactions with type I or type VIII polysaccharide. The modified gamma globulin would also agglutinate type III pneumococci *in vitro* but not types I or II. Mouse protection tests and swelling tests have not yet been carried out.

The earlier Russian attempts to synthesize specific antibodies were mainly undertaken for their theoretical interest, since substitution of relatively low titer artificial antibodies for high titer natural immune serums was of little clinical promise. With the wide use of human plasma banks at the present time, however, practical interest is aroused. If a conversion of normal human plasma globulins into immune globulins is feasible, artificial immune human plasma banks may become a subject of future clinical research. In this eventuality the California biochemists will have rendered a distinct service to clinical medicine by suggesting a definite chemical theory to replace the tentative metaphors of the earlier immunologic theorists.—*Journal of the American Medical Association.*

SCIENTIFIC BOOKS

THE FOURIER SERIES

Fourier Series and Orthogonal Polynomials. Number Six of the Carus Mathematical Monographs. By Dunham Jackson. viii + 234 pages. Chicago: Open Court Publishing Company. 1941.

The topics dealt with in the above monograph bulk large both in the literature of pure and of applied mathematics. The study of Fourier series and related developments in orthogonal functions, together with their application to problems of mathematical physics, dates back to the middle of the eighteenth century. Such study has had a continuous development since that time at the hands of many mathematicians of first rank, as well as lesser lights, and continues to be a live and important part of current mathematical research.

In preparing a book of moderate size on subject-matter of such scope which will be within the comprehension of readers having an adequate grasp of the calculus, the problem of selection of material is a difficult one. No two writers would be likely to make precisely the same selection, but the reviewer agrees in the main with the judgment of the author. The theory of Fourier series itself is dealt with in sufficient detail to enable the reader to appreciate the analytic difficulties that arise in justifying mathematically the formal solutions of the important boundary problems in mathematical physics. Other developments of greater complexity, such as the Legendre and Laplace series and the developments in Bessel functions are naturally treated with less detail but are dealt with in such a manner as to exhibit their analogy with trigonometric series.

In most cases the rigorous treatment of the properties of the development in question, needed to justify the formal solutions of the physical problems, are available in other literature cited by the author when not given in the book. An exception is found in the case of the developments in Bessel functions. One would naturally expect that reference to a work of such an encyclopedic character as Watson's "Theory of Bessel Functions" would cover this point, but this is not the case. For most of the standard boundary value problems, the uniform convergence (or the uniform summability by some regular method) of the development in the neighborhood of the origin is needed to justify the formal solutions. Such uniform convergence and uniform summability have been established in two papers by the reviewer.[1] They can not be inferred from the discussion of convergence and summability in Watson's treatise or from other standard discussions of these questions.

From the standpoint of readers of Science who are more interested in the application of the theory of orthogonal functions to the solution of boundary value problems of mathematical physics than in the mathematical refinements of the subject, a valuable feature of the book is found in the rapid but elegant approach to such application that is found in Chapters IV and V. It is quite feasible to begin with these chapters and take up later the more delicate questions of analysis that are involved. The references to preceding chapters that are contained in the chapters in question facilitate such a process.

It is natural to expect that in a book on orthogonal functions by one of the leading authorities on orthogonal polynomials a considerable percentage of space would be devoted to the theory of such polynomials, and this is the case. In addition to the discussion of Legendre polynomials, to which reference has been made, there is a chapter on the general theory of orthogonal polynomials, followed by separate chapters on Jacobi polynomials, Hermite polynomials and Laguerre polynomials, and a chapter on the convergence of developments in such functions. In the discussion of Hermite and Laguerre polynomials applications are given which connect up with Schrödinger's wave equation.

To sum up the book as a whole, it can be regarded

[1] Transactions of the American Mathematical Society, Vol. XII (1911) and Vol. XXI (1920).

as an admirable solution of the difficult problem faced by the author: namely, to present an introduction to a vast theory with deep roots in both pure and applied mathematics, that would be intelligible to readers without great mathematical sophistication. A proper balance between formal applications and rigorous analysis has been maintained, and the approach in general has the clarity and elegance that one has come to expect from this particular author. For those who wish to begin the study of the field in question or for those who wish to prepare an introductory course on the subject, the book is equally useful. And we may add that the more sophisticated readers interested in the field will also find many items worthy of their attention, and many important unifications.

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HYDROLOGY

Hydrology. Edited by OSCAR E. MEINZER. xi + 712 pp. New York: McGraw-Hill Book Company.

THIS book, which is the latest addition to a series of monographs sponsored by the National Research Council, eight of which have been previously issued, each treating of a particular phase of the physics of the earth, treats of water as it comes from the atmosphere to the surface of the earth in the form of rain and snow, passes over and through the crust of the earth as surface water and ground water and returns again by evaporation and transpiration to the atmosphere in a never-ending cycle, now commonly known as the hydrologic cycle. On the enormous and continuous exchange of water and water vapor between the land and water surfaces of the earth and its atmosphere, which constitutes that cycle and which is comparable in average magnitude with the combined flood discharges of 200 rivers of the size of the Mississippi, man is absolutely dependent for vital supplies of fresh water. Although he is interested in that portion of the cycle related to the ocean which is invaluable to him for purposes of transportation, which furnishes much of the water of evaporation that is later precipitated on the land and which affects in other ways the climates of the land surfaces and, therefore, his comfort and happiness, his greatest interest in the water of the hydrologic cycle relates to that portion of it which falls on the land and is used by vegetation or is possibly available for many human uses as it flows over and through the crust of the earth in the form of surface water and ground water. That portion, which is replenished by precipitation and depleted by evaporation, is complicated by diversities in topography and vegetation of the earth's surface, by variations in porosity of soils and rocks and by the activities and works of man. It is to that complicated portion of the cycle that the major part of the book is devoted, and properly so, since man's interest in the hydrologic cycle and the science of hydrology will continue to be excited, as it has been in the past, by their relation to the practical problems associated with the use of water rather than by the theories related to an abstract science.

In the introductory chapter, Dr. Meinzer defines the science of hydrology, outlines the phases of the hydrologic cycle and its relation to the problems of human life and traces the history of that science from its birth in the false concepts of the ancients, through the gradual development of the present rational and practical science, as a progressive growth resulting from the work of many students of the last 300 years. With his characteristic modesty, Dr. Meinzer has failed to mention, except casually, his own important contributions to those phases of the science that relate especially to the measurement, recharge and recovery of the water that is stored in or flows through the ground—a phase of the hydrologic cycle that is of relatively minor magnitude but is of major value to man.

Each subsequent chapter has been prepared by an expert in the phase that he discusses. Precipitation is presented by Merrill Bernard; the reverse processes of evaporation and transpiration are presented by Sidney T. Harding and Charles H. Lee. The courses and progress of flow of water over and through the crust of the earth are presented under several topics: snow, ice and glaciers are discussed by James E. Church and François E. Matthes; characteristics of surface runoff, by Adolph F. Meyer, Charles H. Pierce, LeRoy K. Sherman, William G. Hoyt, Royal W. Davenport, Clarence S. Jarvis and Walter B. Langbein; storage and control of water, by William G. Hoyt; prediction of runoff, by Royal W. Davenport; ground water and its movement, by Oscar E. Meinzer and Leland K. Wenzel; infiltration, by LeRoy K. Sherman and George W. Musgrave; soil moisture, by Karl v. Terzaghi and Leonard D. Baver; physical changes produced in and by water, by William H. Twenhofel, Harry R. Leach, Lorenz G. Straub, Charles S. Howard and Margaret D. Foster; and special conditions produced in limestone, by Allyn C. Swinnerton, and in lava rock, by Harold T. Stearns.

The volume as a whole constitutes an authoritative presentation of the present knowledge of the science of hydrology and of the hydrologic cycle whose continuity and reasonable uniformity in action at any place are of major importance. Man has been dependent, at all stages of his development, on the availability of supplies of water, first, for domestic use and later, for transportation, irrigation, generation of power, industrial-process uses and, finally, for air conditioning. What future new uses for water may arise, no one can predict in detail. If, however, a reliable

forecast of future needs can be made on the basis of experiences of the past, progress in man's development must be assumed to lead inevitably to increased future uses of and demands for water. This monograph on hydrology has, therefore, not only an interest for students of science but also great practical value to those engineers who must apply science to the changing and growing needs of man.

Nathan C. Grover

United States Geological Survey

REPORTS

THE PENNSYLVANIA COMMITTEE FOR THE PROMOTION OF SCIENCE IN SECONDARY EDUCATION[1]

There has been a growing feeling among members of collegiate departments devoted to teaching in the sciences that introductory instruction in secondary schools in the sciences has been below a desirable standard. The present war emergency has suddenly turned the spotlight upon this condition. Were facilities in mathematics and science instruction many times greater than they are, the improved pre-induction training on the part of inductees into the Services would play a tremendous part in increasing effectiveness of our Services and their equipment.

Admittedly the circumstances influential in determining the present status of science instruction in secondary schools are varied and complex. No one factor is probably paramount in importance. But clearly the amount of training possessed by individual teachers of the sciences in the subject-matter taught is a factor of very high importance. It is the feeling of the overwhelming majority of the college science teachers of Pennsylvania that only when adequate training in subject-matter is required will teachers of the sciences in secondary schools be able adequately to build up the quality of high-school work in this field. Furthermore, in a scientific age the need for such building up seems self-evident.

On account of the growing feeling of the inadequacy of science instruction in secondary schools, the various organizations of college teaching scientists in the State of Pennsylvania, whose names are subscribed to this letter, each appointed a committee to consider the problem. Out of these committees, the central coordinating committee whose names appear below was chosen to deliberate upon remedial measures. This latter committee has met frequently over several months and has earnestly considered every phase of the situation from the point of view of the schools, the teachers, and the public welfare. Their considered opinions are herein crystallized.

It seems imperative that requirements for teacher certification in secondary schools in the fields of science be reviewed and changed. The committee, whose names and the names of the organizations they represent are subscribed below, has considered carefully this problem and respectfully request the privilege of submitting the following recommendations:

(a) The certification "science" should be abolished and become ineffective at once.

(b) The certification in "physical science" should be valid only on the provisional college certificate, and only if at least eight semester hours each in physics and chemistry and a total of 18 semester hours together shall have been earned.

(c) On the permanent college certificate for the secondary field an applicant should be certified to teach in biology, chemistry or physics only on completion of 18 semester hours in the science in which he is certified.

(d) The use of temporary or emergency certification should be carefully restricted.

(e) The certification "General Science" should only be valid for courses in that subject in the ninth grade or lower and should require a minimum of eight semester hours in *each* major component science, physics, chemistry and biology. Any composite courses given at a higher level should require certification in each component science.

(f) The granting of the Permanent College Certificate for the secondary field should be governed by the following:

Permanent College Certificate for the Secondary Field

The issue of this certificate is dependent upon the possession of the qualifications required for the provisional college certificate and in addition thereto, not less than three years of successful teaching experience in the appropriate field in the public schools of the Commonwealth with a satisfactory rating and *either* (a) *the completion of advanced education to the amount of thirty semester hours, or* (b) *the earned master's degree.*

The required preparation is to be completed at a minimum rate of not less than six semester hours every three years.

Such advanced education is to be subsequent to the issuance of the baccalaureate degree and should be related to the subjects or fields in which the candidate is certificated to teach or be in the general field of education, at least half of which or fifteen semester hours however being in the subject-matter of the field of certification.

The provisional college certificate may be renewed for an additional period of three years on a rating of "satisfactory" plus six semester hours or more of advanced education, at least half of which or three hours being in the subject-matter of the field of certification.

The above regulations would not be retroactive nor

[1] Report of the committee to the State Council of Education, signed by W. H. Trytten, *Chairman.*

affect secondary teachers in service. The proposed regulations would become effective for those who receive the provisional college certificates subsequent to September 1, 1942.

We believe recommendation (a) to be of high importance. Under the certification "science" a person may actually be certified to teach the sciences, with as little as three semesters in the science he may be asked to teach, a condition we believe to be indefensible.

Recommendations (b) and (c) are concerned with correcting the present practice of allowing certification in the sciences by groups of sciences which thereby permits certification of inadequately trained persons. If a person is poorly trained in physics and chemistry both, he is no better trained by certifying him in natural science.

Recommendation (e) differs very little from a similar recommendation circulated under date of January 12, 1939, by the Department of Public Instruction and sent to school officials throughout the state. The essential difference is that this committee believes that positive safeguards must be set up to insure that subject-matter training go hand in hand with professional training. It is felt that it is just as important to know what you teach as how to teach it. Particularly it is desired to emphasize that certification in more than one science should occur only upon completion of adequate training in the subject-matter (18 semester hours) in each of the sciences concerned.

This committee believes that now, when the need for more adequate science instruction is so clear, is the time to determine upon new standards. It is true that the scarcity of teaching personnel may force temporary measures under emergency conditions. But a permanent policy may nevertheless be set up now. The undersigned respectfully urge upon you the need for taking constructive action in this connection.

The membership of this committee and the societies represented are as follows: Dr. M. H. Trytten, *Chairman,* National Defense Research Committee—Pennsylvania Conference of College Physics Teachers; W. H. Michener, *Secretary,* Carnegie Institute of Technology—Association of Physics Teachers of Western Pennsylvania and Environs; Dr. E. L. Haenisch, Villanova College—Pennsylvania Chemical Society; Dr. John C. Johnson, Edinboro State Teachers College—Pennsylvania Academy of Science; Dr. C. O. Oakley, Haverford College—Philadelphia Section of the Mathematical Association of America; Dr. F. W. Owens, Pennsylvania State College—Allegheny Mountain Section of the Mathematical Association of America; Dr. F. C. Stewart, Pennsylvania State College—Allegheny Mountain Section of the Society for the Promotion of Engineering Education.

SPECIAL ARTICLES

THE GROWTH-STIMULATING EFFECT OF BIOTIN FOR THE DIPHTHERIA BACILLUS IN THE ABSENCE OF PIMELIC ACID[1, 2]

IN a study of the accessory growth factors for the diphtheria bacillus, Mueller[3] discovered that pimelic acid stimulated the growth of the Allen strain and some of the Park 8 strains.[4] Pimelic acid proved to be specific in this effect in so far as the higher and lower homologues of this dicarboxylic acid were inactive. In an attempt to detect pimelic acid in connection with other work in this laboratory, it occurred to us that the effect of pimelic acid on the growth of the diphtheria bacillus might be utilized as the basis of a microbiological assay method for this compound. We have found that cultures of the Allen strain[5] which were recently transferred from Loeffler serum medium to a liquid medium grew very little in the absence of pimelic acid, whereas the addition of increasing amounts of pimelic acid within certain limits resulted in proportional increments of growth. The procedure gives promise as a method for the bio-assay of pimelic acid.[6] The idea of utilizing the diphtheria organism for this purpose has also led us to the recognition of an interesting relationship between pimelic acid and biotin.

Several years ago we tested vitamin H (biotin)

[1] The authors wish to express their appreciation to the S.M.A. Corporation for a research grant which has aided greatly in this work. They also wish to thank Mr. W. O. Frohring and the Research Staff of the S.M.A. Corporation and Dr. R. Major and the Research Staff of Merck and Co., Inc., for supplies of biotin.

[2] After this work had been initiated by us we learned that Dr. E. E. Snell reported at the annual meeting of the Federation of American Societies of Experimental Biology held at Boston that Dr. R. E. Eakin in Professor Roger J. Williams's laboratory had found that a larger amount of biotin was synthesized by *Aspergillus niger* when pimelic acid and cystine were added to the medium.

[3] J. H. Mueller, *Jour. Biol. Chem.*, 119: 121, 1937; and *Jour. Bact.*, 34: 163, 1937.

[4] J. H. Mueller, *Proc. Soc. Exp. Biol. and Med.*, 36: 706, 1937.

[5] This strain was made available through the generosity of Professor J. Howard Mueller.

[6] The liquid medium employed was the same as that employed by Mueller (*Jour. Bact.*, 36: 499, 1938). The culture was transferred from the solid Loeffler medium to the liquid medium, which contains pimelic acid and was incubated at 34–35° C. At the end of 48 hours a loop-full (2 mm loop) of the pellicle was transferred to a second tube of liquid medium. Solutions to be tested together with the pimelic acid-free medium were inoculated with a loop-full of the pellicle which formed in the second tube after incubation for 24 hours at 34–35° C. Micro-Kjeldahl determinations were used to determine the amount of bacterial nitrogen produced in 64-hour cultures incubated at 34–35° C., according to the procedure used by Mueller (*Jour. Bact.*, 29: 383, 1935).

preparations for their effect on the growth of the diphtheria bacillus, and under the conditions of our experiment we found that biotin had no effect on the growth of this organism. Recently Landy *et al.*[7] reported that *Corynebacterium diphtheriae* (Park 8) grows in the absence of free biotin in the medium. While we were considering the utilization of the diphtheria organism for the assay of pimelic acid it occurred to us that perhaps pimelic acid might be a precursor for the bio-synthesis of biotin by these strains of the diphtheria bacillus. If this were the case biotin might support the growth of these organisms in a pimelic acid-free medium. This possibility was explored experimentally and we wish to report that in the absence of pimelic acid we find that biotin is an accessory growth factor for the Allen strain diphtheria bacillus.

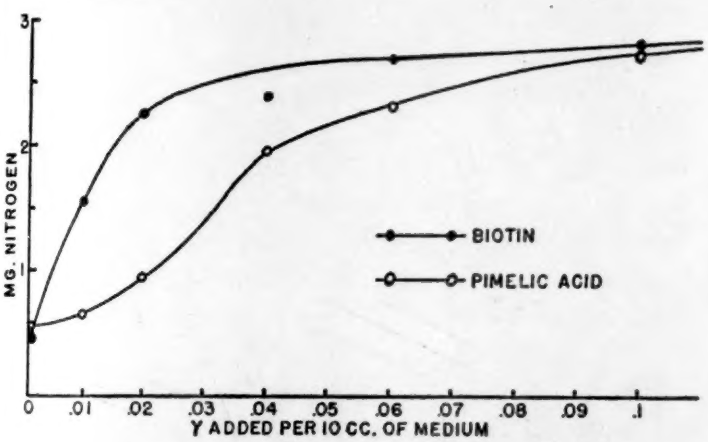

FIG. 1. Curves showing the effect of biotin and pimelic acid on the growth of the Allen strain diphtheria bacillus. Growth is expressed as milligrams of bacterial nitrogen per 10 cc of medium. Maximum growth was obtained by 1.5 γ of either biotin or pimelic acid, which produced respectively 4.5 and 4.7 mg of nitrogen.

Chart I shows the amount of growth obtained with both biotin and pimelic acid from 0.01 to 0.10 γ per 10 cc of medium. Under the conditions employed in these experiments maximum growth was obtained with approximately 1.5 γ of each, pimelic acid producing slightly more growth than biotin at this maximum level. Biotin, however, was more effective than pimelic acid at low concentrations. The addition of biotin to a medium containing a maximum amount of pimelic acid did not increase the growth obtained and undoubtedly explains the previous results which indicated a lack of an effect on the growth of diphtheria bacillus on the part of biotin.

It is worth noting that avidin prevents the growth-stimulating effect of biotin for the diphtheria bacillus when biotin is added to a pimelic acid-free medium, but does not prevent the growth-stimulating action of pimelic acid. It was also found that pimelic acid was unable to replace biotin in its growth-stimulating effect on yeast.

These experimental results may be interpreted on the basis of the pimelic acid being utilized by this diphtheria bacillus for the synthesis of biotin. The results obtained are highly suggestive of this but can not be regarded as conclusive proof. These findings raise the interesting possibility that other organisms which are capable of growing without biotin in the medium may be able to utilize pimelic acid in the same manner. It should also be pointed out that pimelic acid may have to be taken into consideration in nutritional studies in which the synthesis of biotin by bacteria in the intestinal tract may play a rôle.

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KARL DITTMER
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[7] M. Landy, D. M. Dicken, M. M. Bicking and W. R. Mitchell, *Proc. Soc. Exp. Biol. and Med.*, 49: 441, 1942.

A BIOSYNTHESIS OF BIOTIN[1,2]

PIMELIC acid, unlike other growth factors for bacteria and yeast, has been found significant for only a single type of organism, the diphtheria bacillus.[3] However, the close relationship between the B-vitamins and the nutrilites for lower forms of life suggests that pimelic acid is a compound of general biological importance.

A possible physiological role of pimelic acid occurred to us when du Vigneaud, Hofmann and Melville reported tentative structural formulae for biotin.[4] These investigators have carried out chemical degradations which indicate that the biotin molecule probably contains the side chain-$CH_2CH_2CH_2CH_2COOH$. The presence of such a radical in the structure of biotin suggested that pimelic acid might serve as a precursor in biological syntheses of biotin. Experimental studies we are reporting indicate this to be the case.

It seemed desirable to choose for the biosynthesis studies an organism whose rate of growth is not affected by either biotin or pimelic acid. *Aspergillus niger,* an easily cultured mold satisfying these conditions, was selected. As biotin does not stimulate the growth of this mold, it was assumed that it possessed

[1] The material reported in this note was included in a discussion by Dr. E. E. Snell at the annual meeting of the Federation of American Societies of Experimental Biology at Boston on April 2.

[2] This study was aided by a grant from Standard Brands Incorporated to Dr. R. J. Williams (University of Texas), and by a grant from the John and Mary R. Markle Foundation to Dr. Tom D. Spies (Nutrition Clinic, Hillman Hospital).

[3] J. H. Mueller, *Jour. Biol. Chem.*, 119: 121, 1937; *Jour. Bact.*, 34: 163, 1937.

[4] V. du Vigneaud, K. Hofmann, D. B. Melville, *Jour. Am. Chem. Soc.*, 64: 188, 1942.

the mechanism necessary for the synthesis of biotin. It was necessary that pimelic acid have no effect on the growth of the organism used; otherwise, increased biotin production in cultures containing pimelic acid could be attributed to an increased growth of the cultures rather than to a conversion of pimelic acid into biotin.

The biotin free medium for yeast,[5] adjusted to pH 5.2, was used for culturing the mold. Sterilized 12 cc cultures (2 cc of addendum plus 10 cc of medium) were each inoculated with 2 drops of a suspension of *Aspergillus niger* spores. After 72 hours' incubation at 30° C., the cultures were autoclaved and filtered, and the biotin content of the filtrate determined by the yeast assay method.[5]

Results of a typical experiment, tabulated in Table I, demonstrate the activity of pimelic acid in promoting the synthesis of biotin.

TABLE I

Culture	Addendum per culture	Biotin content of filtrate of culture
1	None	0.006 microgram/culture
2	None	0.007
3	1 mg pimelic acid	0.096
4	1 mg pimelic acid	0.108
5	1 mg cysteine	0.011
6	1 mg cysteine	0.016
7	1 mg cystine	0.010
8	1 mg cystine	0.012
9	1 mg pimelic acid + 1 mg cysteine	0.192
10	1 mg pimelic acid + 1 mg cysteine	0.180
11	1 mg pimelic acid + 1 mg cystine	0.216
12	1 mg pimelic acid + 1 mg cystine	0.180

In spite of the difference in the amount of biotin produced, there were no visible differences in the growth of the cultures.

In subsequent studies, it was found that the maximum production of biotin could be obtained with pimelic acid concentrations of 20 micrograms per 12 cc culture.

The lower homologues of pimelic acid, succinic, glutaric and adipic acids, and an isomer, β-methyl adipic acid, were tested and found inactive. The higher homologues, suberic and azelaic acids, however, have activity comparable to pimelic acid. The biotin active substance produced from any of the active dibasic acids react in the usual manner with avidin.[6]

Cysteine or cystine, sources of organic sulfur, were found to enhance the effect of pimelic acid. A study of the supplementary action of these and other sulfur-containing compounds has given erratic results, but this problem is being investigated further.

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ESTHER A. EAKIN
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UNIVERSITY OF TEXAS

[5] E. E. Snell, R. E. Eakin and R. J. Williams, *Jour. Am. Chem. Soc.*, 62: 175, 1940.

[6] The physiological relationship between pimelic acid and biotin has been demonstrated independently by du Vigneaud, Ditmer, Hague and Long, who have shown that biotin is a growth stimulant for the diphtheria bacillus in the absence of pimelic acid.

TETRAPLOIDY IN ANTIRRHINUM MAJUS INDUCED BY SANGUINARINE HYDROCHLORIDE

IN the fall of 1941, Dr. Glenn A. Greathouse, discussing his work on the influence of alkaloids on the growth of fungi, mentioned that the alkaloid sanguinarine had produced peculiar swellings in the hyphae of certain fungi. This observation led the author to try the effect of sanguinarine on seedlings of *Antirrhinum majus* to determine whether it would produce polyploidy in a manner similar to colchicine.

In December, 1941, 100 seedlings of Antirrhinum (snapdragon, variety White Prosperity) were treated by placing a drop of 0.2 per cent. sanguinarine hydrochloride solution on the terminal growing point of each. At the same time, 100 seedlings of the same variety were treated with 0.2 per cent. colchicine, another 100 seedlings were treated with 0.2 per cent. lycorine (tried because, like colchicine, it is derived from monocotyledonous plants), and another 100 seedlings were left untreated for a check.

The toxic effect of the sanguinarine was very obvious within 24 hours after treatment, practically all the seedlings showing some dead tissue where the drop had been applied. At first the growth of the seedlings was greatly retarded, but after several weeks normal growth was resumed and the plants were examined for abnormalities of the leaves or stems. Eighteen of the plants were selected as appearing somewhat abnormal, and these were repotted for growing to maturity. While these plants appeared to have larger and thicker leaves than normal, the leaves had none of the roughened or wrinkled appearance characteristic of the seedlings treated with colchicine. Of these 18 plants, 9 were lost, due to an error in handling, but the remaining 9 were grown to maturity, and chromosome counts were made from propionocarmine smears of the pollen-mother-cells. Five of the plants were found to be tetraploids, and the remaining four diploids. Two of the tetraploids had some diploid branches, which had emerged below the point of treatment. Because some of the plants were lost, we can only say with certainty that tetraploidy was induced in at least 5 per cent. of the treated plants. This compared favorably with the results from 100 seedlings treated with colchicine, in which 4 tetraploids were found (a much higher percentage of tetraploidy has been induced by colchicine, however, using the same method of treatment, but repeating it 3 or 4 times at 3-day intervals). No tetraploids were found

among the 100 untreated check plants, nor were any found among the 100 plants treated with lycorine.

Preliminary experiments on the effect of sanguinarine on mitosis in excised root tips of Lilium have indicated that its effect is similar to that of colchicine in producing shortened and split "C-chromosomes." A more detailed account of these studies will be published later.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

BACTERIAL ACTIVITY IN DILUTE NUTRIENT SOLUTIONS[1]

Most media designed for the growth of heterotrophic bacteria contain from 0.1 to 1.0 per cent. of organic matter, and it is generally claimed[2] that the minimum concentration required for their multiplication ranges between 0.001 and 0.01 per cent., or between 10 and 100 mgm/l. This is considerably higher than the concentration of nutrients generally found in nature in lakes, soil solutions or sea water. Sea water contains an average of 4 or 5 mgm/l of organic matter, much of which is fairly refractory to bacterial decomposition,[3] yet there is evidence that bacteria multiply and are otherwise active in sea water. In fact, the bacterial population may increase from a few hundred bacteria per ml of freshly collected sea water to several million after a few days' incubation in the laboratory.[4]

In order to approach the minimum quantity of organic matter which limits bacterial activity, an organic matter-free mineral solution was prepared. To it was added enough peptone to give concentrations ranging from 1.0 to 100 mgm/l, after which test-tube quantities were inoculated with a loopful of organic matter-free water containing from 10 to 100 living bacterial cells. After thoroughly mixing, loopful quantities were streaked on nutrient agar plates and the procedure was repeated at intervals of 24 hours. So few cells were introduced that rarely did any growth occur on the plates inoculated initially. However, after 24 hours' incubation at 22° C ten out of twelve of the cultures tested had multiplied enough to produce an abundant growth on the nutrient agar when loopful quantities were transferred. Since the controls were properly negative, the experiment showed that the cultures had multiplied in the most dilute of the peptone mineral solutions, although only the solutions containing more than 10 mgm/l of peptone were turbid. Similar results were obtained in dilute glucose ammoniacal mineral solutions.

It is not surprising that the dilute nutrient solutions do not become cloudy with bacterial growth because it requires around a billion cells per ml of the size of those being used to produce perceptible turbidity. Even if all the organic matter (1 to 10 mgm/l) were assimilated, there wouldn't be enough to give the requisite number of cells to produce a turbid solution. Moreover, many of the cells in dilute nutrient solutions grow attached to the walls of the test-tube.[5]

Quantitative results were obtained by inoculating glass-stoppered bottles filled with mineral solution treated with concentrations of glucose, ranging from 0.1 to 10 mgm/l. After different periods of time the bacterial populations were determined by plate count procedures and the dissolved oxygen content of the water was determined. The results showed that the bacteria multiplied in concentrations of glucose as low as 0.1 mgm/l and that this amount of glucose was completely assimilated in four or five days at 22° C. Ten to twenty days were required for the complete assimilation of concentrations of glucose as large as 1 to 5 mgm/l. Between 60 and 70 per cent. of the glucose was oxidized and the remainder was converted into bacterial protoplasm. Similar results were obtained with glycerol, ethanol, succinic acid and lactic acid. As will be elaborated elsewhere solid surfaces seem to facilitate the assimilation of dilute nutrients. Under proper conditions it is believed that concentrations of utilizable organic matter considerably smaller than 0.1 mgm/l will provide for bacterial multiplication.

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[1] Contribution from the Scripps Institution of Oceanography, New Series No. 173.

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PRESERVING PLANT VIRUSES IN VITRO BY MEANS OF A SIMPLIFIED LYOPHILE APPARATUS

Most plant viruses are readily inactivated *in vitro*. This characteristic makes it difficult to interchange viruses with other workers for comparison studies. For this reason it has been considered desirable to devise some method of so treating a plant virus that its virulence could be retained. Since oxidative action

was considered to have an effect upon the longevity of viruses, experiments were designed to determine whether the absence of oxygen would prevent inactivation of certain viruses.

Two potato viruses, Y-virus and Canada streak virus, were used in these studies. These viruses when extracted in air have a longevity at 15° C. of about 72 hours and 120 hours, respectively.

In order to extract the plant juices in CO_2 a special metal box was constructed, in the front of which were two round holes to which rubber sleeves were attached, permitting the operator free movement with hands inside the box. Above these openings a pane of glass was inserted in such a manner that it could be easily removed, thus leaving an opening through which plant material and equipment could be placed inside the box. Solid carbon dioxide (dry ice) was placed in this container. After the CO_2 gas had replaced the air, the box was closed and it was ready for operation. Potato leaves infected with a virus were placed inside this chamber and crushed in a mortar. A few cc of extracted juice were then put into each of several glass tubes. After these tubes were covered with clamped rubber tubing, they were removed from the chamber and attached to a modified lyophile apparatus, which can be easily constructed.

This lyophile apparatus consists of a manifold made of an inverted 2-liter round-bottom flask (Fig. 1, A) from the sides of the bulb of which extend two

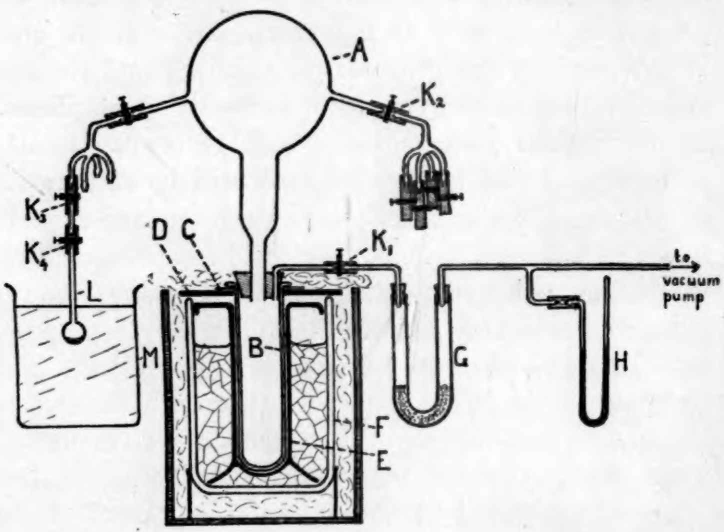

FIG. 1.

pieces of glass tubing. Each of these terminates in four outlets, to which tubes containing virus can be attached by means of rubber vacuum tubing. The sections of tubing K_3 and K_4, with screw clamps, allow removal of the tubes without releasing the vacuum. Four tubes L can be suspended in the air or be kept at a required temperature by submersion in a container M. The mouth of the flask A is fastened by means of a rubber stopper to a wide glass tube B used as a condensing chamber, which dips into a 2-gallon insulated vacuum jar F filled with a mixture of di-ethylene glycol and solid CO_2. The wire basket E permits easy removal of this chamber. The condensing chamber has a flared-out mouth which rests on a hard rubber ring D, which in its turn rests on the vacuum jar. The soft rubber washer C is used as a cushion. In the rubber stopper used to connect the manifold and condensing chamber, a glass tube (8 m.m.o.d.) is inserted which leads to a U-tube G filled with dryerite, to a manometer H, and finally to a vacuum pump. In order to facilitate cleaning, to prevent breakage and to aid in the detection of leaks, tubing and clamps K_1 and K_2 are used.

Dehydration of the virus was effected by a combination of evacuation, condensation and chemical drying, and resulted in formation of a thin film of solid particles inside the tubes L. The tubes were then clamped, removed from the lyophile apparatus, sealed and stored at room temperature. At monthly intervals a few tubes were broken and the contents of each used to inoculate 10 potato plants. Preparations of both the Y-virus and the Canada streak virus continued to produce 100 per cent. infection as long as 4 months after extraction and dehydration. Some of the tubes were improperly sealed and permitted air leakage; in all such cases the virus was invariably inactivated, indicating that oxidation had a direct or indirect effect on the destruction of the virus. Experiments are now in progress to secure additional information on this problem.

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